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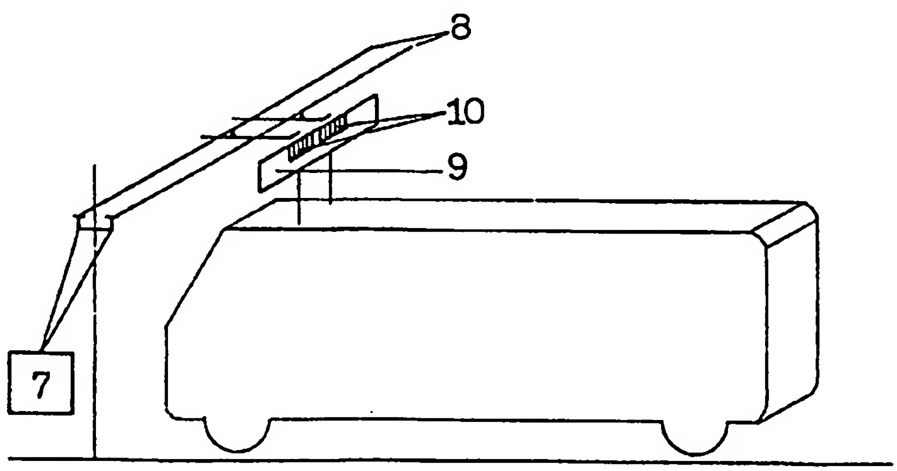

(57) Abstract

Method and device for energy accumulation and recuperation in electric cars and electric vehicles with electric or hybrid drive. The method enables power supply of electric cars and electric vehicles at points of the electric contact system, which are kilometers away from one another. The supply is done while the MV is moving (without it being necessary to stop for supply) which is the basic advantage of this method. Besides, this method enables greater freedom and manoevrability of the MV, fed by the electric contact system; makes it possible to remove the electric contact system above the basic part of the route, replacing it with separate points and avoids the limitations concerning the height of the transported cargo. It is characteristic for the device that it uses a capacitor bank for temporary accumulation and transmission of electric energy and ensures economy (reduction of power consumption for motion) of the MV and raises the acceleration (dynamics, demarage) of the latter, using normal power motors, which are nowadays traditionally used in MV.

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METHOD AND DEVICE FOR ENERGY ACCUMULATION AND RECUPERATION

Technical field:

The invention refers to a method and device for energy accumulation and recuperation, which is applied in different types of motor vehicles (MV), driven by electric motors or in combination therewith - hybrid MV.

Previous state of technology:

A method is known according to which in the electric vehicles with non-autonomous power supply by means of contact system (trolley busses, trams, electricity powered trains) efficient enough power recuperators are applied for returning the energy, liberated during speed reduction and braking back into the mains. For the purpose the electric motors of the electric vehicles perform the functions of electric generators and return energy into the mains, while in braking regime.

It is known that in the motor vehicles, which are autonomously fed by individual source of energy for power recuperation, liberated during speed reduction and braking, power recuperators are applied. For the purpose the electric motors of the MV perform the functions of electric generators and accumulate electric energy into storage batteries or fuel cells, while in braking regime (Reference No. 4).

It is known that hybrid electric automobiles exist, containing an electric generator, driven for instance by an internal combustion engine or another type of engine, which also contain an accumulator, leveling out (equalizing) the load of the electric generator caused by the driving motors of the electric automobile, which in its turn makes possible the use of considerably less powerful motors than those applied for automobiles without such devices. Recently automobiles with possibility for

combined drive were designed. They are driven by the basic non-electric motor and at certain periods of time, for instance at starting or during overtaking, power from the additional electric motor is added to the power of the first motor (Reference No. 4).

In the existing electric cars numerous variants exist of connecting the separate aggregates and the storage batteries - in parallel, serial and mixed circuits, where the accumulator works in different modes: as a basic or supplementary source of energy, as a buffer unit, as a storage unit for recuperated energy, etc. Such accumulator may in the course of work change its basic designation. There exist electric cars, which are run in urban environment making use of the storage battery as a basic source of energy, and while moving in the country they use an internal combustion engine, and the accumulator performs the function of a buffer. A drawing, showing the interconnection between the different elements is available in Reference No. 4, on pp. 62-67. The electric circuit presented on the drawing is a source of electric energy (electric generator, fuel cell, etc.), connected to a unit for electric energy regulation, transformation and re-directing (redistribution), which is in turn connected to a storage battery and to an electric motor (electric motors), driving the MV able to work in a generator mode as well for recuperation in case of slowing down and braking.

Some shortcomings of the known methods and devices are that after a certain number of charge-discharge cycles the storage batteries get destroyed and the efficiency of the accumulators is about 80%. Besides, the storage batteries may not work with high values of charge-discharge currents.

A tendency in the designing of MV, regardless of the type of their basic driving energy sources and of whether the energy is transformed prior to its usage into electric, is to ensure through more powerful motors possibilities for achieving higher speed and greater acceleration (dynamics, demarage).

Technical essence of the invention:

The aim of the authors was to design a method and device, enabling greater maneuverability and freedom of motion of the MV, fed from contact system, and for autonomously fed MV - to enable achievement of great acceleration (nowadays achieved through powerful engines) with normal, traditionally used engines and at the same time to reduce energy consumption for MV motion, retaining the above mentioned advantage concerning acceleration.

The goals were achieved through the introduction of a new intermediary element in the electric circuit between the power source and the driving electric motor (motors), which temporarily accumulates the power, generated by the electric power source and/or resulting from recuperation in the drive engines. This element represents a capacitor bank, i.e. the authors build-in a large capacity capacitor bank, which plays the role of a power accumulator, and also assumes the function of fast real-time intake of the power coming from the electric energy sources, recuperated power included, as well as of feeding the latter to the electric motors for MV driving, which means that it plays the role of electric energy buffer.

The proposed large capacity capacitor bank may be incorporated in all possible drive circuits of motor vehicles with electric or hybrid drives (Reference No. 4) - serial, parallel and combined. In particular they may replace the storage batteries in the respective circuits (Reference No. 4), and even be used in applications where charging (and discharging) with currents larger than the admissible currents for storage batteries is required (with exception of the cases when the storage battery is the basic power source; in such cases the capacitor bank is incorporated as an additional one).

The new element - the capacitor bank, is only used to temporary accumulate and transmit power during motion of the MV - during the time of braking,

respectively accelerating, and for a short periods of moving (from one to a few minutes, depending on its capacity and on the power it intakes with time).

The advantages of using the capacitor bank for power accumulation and transmission are as follows:

a) the capacitor fitness is not determined by the number of charge-discharge cycles, as a result of which they are much more durable than the accumulators.

b) The efficiency of capacitors is much higher than that of accumulators, and is equal to nearly 100%.

c) Unlike accumulators and fuel cells, capacitors may be charged and discharged exceptionally quickly - for less than a second, which enables giving-off and intake of large currents towards and from the drive electric motors (in the second case acting in generator mode during braking), which in turn ensures great acceleration (positive and negative) of the MV, without the need of increasing the power of the energy source (fuel cell, solar battery, storage battery, electric generator driven by non-electric engine, etc.) thereof.

Anther advantage of using such an element is that the MV, equipped with it shall always be able to start moving and to reach its maximum speed without prior switching-on of the primary power source of the MV (eventually starting the internal combustion engine), the latter being switched-on (started) while the MV is in motion. Besides, the maximum acceleration of the MV will be theoretically the highest possible and will only depend upon the cohesion of the tires against the roadway, and not upon the power capabilities of the primary sources, due to the fact, that the capacitor bank is able to render the driving electric motors practically any instantaneous power necessary. The latter should be dimensioned accordingly, so that they will only be able to withstand such power for a couple of seconds or parts of a second.

An advantage in using the described element is that it enables the power source of the MV (such as an electric generator, driven by an internal combustion engine) to be run in pulse mode, without disturbing the motion mode, since the capacitor bank stores and supplies power to the driving electric motors of the MV even when the supply source is switched off, thus avoiding the time during which the electric motor engine (if such is used) would perform idle running. The mode now is a consequence of maximum (optimum) power, pause, maximum (optimum) power, pause, ... etc., which brings about fuel saving (especially when the MV moves in urban areas). Additional fuel savings result from the fact, that the application of MV, designed to run with constant revolutions and power becomes possible.

For MV, fed from an electric contact system, the ability of the above mentioned capacitor bank to charge and discharge very quickly and with enormous current values makes a new method possible for power accumulation and recuperation, which could not be attained so far, and which enables greater manoeurability and freedom of motion of the vehicle. When applying this method, the power accumulation from the electric contact system into the MV, or return of the recuperated power into the system takes place while the MV is moving through periodic contacts between the bow collector(s) of the MV and system points, which are kilometers away from one another, without it being necessary for the MV to stop; besides there is no need to extend wires above the whole length of the route of the MV, which is the basic advantage of this method. In such a circuit the power supply of the drive electric motors of the MV from the external (stationary) electric power source (the electric contact system) is done through charging and utilizing the charge of the capacitor bank. While the MV is moving on the road, periodic contacts of the bow collector with the electric contact points of the system are realized thus charging the capacitor bank. The MV continues its motion along the route, utilizing the electric power accumulated in the capacitor bank; prior to exhaustion of the power it encounters other feeding points and the process is repeated.

The method described herein enables returning of electric power from the MV into the system contact points.

A combination is also possible of an external to the MV (stationary) and internal (autonomous) power source in the MV, the latter being switched-on (automatically) when the capacitor bank power drops below a predetermined level, and until then the power from the external to the MV electric power source which is accumulated in the capacitor bank is made use of.

Another advantage of the method described herein is that the electric contact system is situated under the ground, thus it is naturally shielded. It may be additionally shielded through metal cover of cables, thus avoiding electromagnetic pollution. (The electric contact spots, kilometers away from one another and being small in size, may also be successfully shielded.)

At last, but not least, the limitations concerning the height of the transported cargo fall, and this puts an end to spoiling the look of streets and squares with the hanging electric contact system.

Implementation examples:

Fig. 1 represents general view of the device.

On the annexed figure an exemplary version of the device is shown. It consists of an electric power control, transformation and redirection (redistribution) unit - 1, connected to one or several drive and/or power recuperation electric motor(s) - 2, and to a capacitor bank - 3. Unit 1 is also connected to the external, with respect to the device, electric power source(s) - 4, if any.

The external, with respect to the device, electric power source(s) 4 may be situated both outside the MV - electric contact system, and/or inside the MV - a

storage or/and solar battery, or/and fuel cell, or/and electric generator (driven by an internal combustion engine or other kind of engine), etc., referred to in the presentation as "primary sources".

The drive electric motor(s) 2 may be of all known electric motor types, able to recuperate power in generator mode. To this effect, a specific variant of the device is applied in the case when a non-electric motor (internal combustion engine, etc.) drives directly the MV and may at the same time run an electric generator, the electric generator on its part (thanks to previously accumulated energy in the capacitor bank), may in certain periods be switched-on and act as an electric motor as well, for parallel or independent drive along with the non-electric engine. A modification is also possible for the case when the drive electric motors 2 may not run in generator mode.

When primary electric power source 4 is not available, the electric motor(s) 2 shall only serve for power generation while braking (the power is accumulated in the capacitor bank 3) and assist the starting of the MV (using up the energy accumulated through recuperation) - for instance in the case when the non-electric motor of the MV is directly connected to the running gear and is not running an electric generator.

The capacitor bank 3 represents a large capacity battery, able to accumulate energy amounting to hundreds of thousands and even millions joules. In order to facilitate the harmonization of its energy (with respect to current and voltage values) with the sources and/or load, it would be an advantage to divide it into separate batteries with possibilities for parallel, serial or combined connection.

Unit 1 consists of a control and adjustment circuit, voltage or current converters, rectifier groups, etc., interconnected in an appropriate way:

When using an external with respect to the device source of electricity 4 (regardless of whether the source is inside or outside the MV), the electric power

from the latter enters into unit 1 from where it may be transferred for charging the capacitor bank 3 and/or to the drive motor(s) 2, after eventual transformation. Since the capacitor bank 3 is charged with direct current, if the external electricity source is an alternating current one, it is necessary that unit 1 contains a rectifier group through which the bank shall be charged. Due to the fact that the voltage of the capacitor bank 3 depends on the energy accumulated therein (with factory-preset capacity), it is necessary that either the external power source is able to secure voltage, equal to the maximum working voltage of the capacitor bank 3 or/and unit 1 should contain a converter, able to raise the voltage to the necessary value. Unit 1 contains also a circuit (for instance current restrictor), regulating (limiting) the power coming from the source 4, in accordance with the desired charge of the capacitor bank 3 and the power consumed by the drive electric motors 2. In case that no power is consumed, unit 1 may transmit a signal for switching-off of source 4.

It is possible that the capacitor bank 3 both receives energy from the external with respect to the device source(s) 4, and transfers energy back to the source(s), if the latter is (are) rechargeable - a storage battery and/or fuel cell, or able to intake electric energy - an electric contact system. In such case unit 1 should be able to transform the energy from the capacitor bank 3 to current and voltage values suitable for return to the source 4. If electric power is available in capacitor bank 3, it may transmit the latter through unit 1 to the drive motors 2, and unit 1 again has to be able to perform harmonization of the current and voltage values. (In its essence, the circuit contained in unit 1 for feeding the drive electric motors from a capacitor bank, represents a controllable voltage converter, and if the electric motors are A.C. motors - it also contains a D.C. to A.C. converter with frequency regulation.) The feeding of electric energy to the drive electric motors 2 from the capacitor bank 3 may be done in parallel with feeding of electric energy from sources 4. Unit 1, through which electric energy is transmitted to the drive electric motors 2 also ensures regulation of this energy, depending on the desired power and revolutions of the latter (when this device is used in MV - depending on the "accelerator pedal" position).

When and if the drive electric motor(s) 2 recuperate power in a generator mode of braking, they may transmit such power through unit 1 to the capacitor bank 3, or/and to the external with respect to the device electric sources 4, if necessary (in cases of completely or almost completely charged bank; high kinetic energy of the MV in case of sudden braking, which could not be held by the bank; long slopes, etc.) and if the latter are capable of accepting electric energy. In this case unit 1 also contains a circuit, which converts the energy from the electric motors 2 to suitable current and voltage values for charging of the capacitor bank 3 or/and for transfer back to the electric sources 4 (the capacitor bank 3 and/or the electric sources 4 are charged with current, corresponding to the "brake" pedal position, thus ensuring charging thereof and stopping of the MV through certain negative acceleration). Backward transfer of electric energy from the electric motors 2 to the electric sources 4 may also be effected in parallel with back transfer thereof from the capacitor bank.

In order to be able to demonstrate its advantages with respect to drive energy saving in MV, the capacitor bank of the device should be a large capacity one.

Besides, the sum of the energy accumulated in the bank and the kinetic energy of the motion of the MV should not be greater than the energy which the capacitor bank can accumulate (thus it will always be possible for the recuperated energy from eventual braking to be contained in the bank).

When this sum becomes equal to the energy amount that may be contained in the bank, the device switches-off its external power sources, and if the kinetic energy of the MV continues to rise (on a slope), it might transfer energy back to the sources if the latter can intake electric energy (a storage battery, fuel cell or mains).

Other solutions concerning the extent of charging of the capacitor bank, such as for instance it being always partially or even completely charged, even at the

maximum MV speed are also possible. It will then be possible to achieve great acceleration during outrunning of other vehicle, even when it is moving with high speed, however with losing the possibility for energy accumulation through recuperation during sudden braking, i. e. in exchange of certain economy.

The advantages of frugality plus high manoeurability and possibility for great accelerations (demarage) even during motion may be ensured by a capacitor bank capable of accumulating energy greater than the energy needed and sufficient for a MV to start moving and to reach its maximum factory determined speed for a long journey.

In any case the increase of the power capacity of the capacitor bank is an advantage.

Example:

The kinetic energy of a car with mass m=1000 kg, moving at a speed of v=27.7 m/s (100 km/h) is $E=m*v^2/2$ = 383,500 J. The energy E in a capacitor is calculated through the formula $E=C*V^2/2$, where C is the capacity and V is the voltage of the capacitor. There exist (Reference No. 3, p. 165) capacitors with capacity 1F at voltage of 5.5 V with geometric dimensions (in mm) 2*1.9*0.5=1,900 mm^3, which makes E=1*5.5*5.5/2=15 J or energy density of 15/1,900 = 0.00789 J/mm^3. It is thus evident that in order to contain 383,500 J (the whole energy at halting of the MV), the capacitor bank should have dimensions 383,500/0.00789=48,606,000 mm^3 - less than 0.05 m^3 or weight under 100 kg.

One has to bear in mind that if a monolithic (and not mechanical collection of small capacitors) capacitor bank is made, the latter will have even smaller dimensions and weight.

For a speed of 160 km/h, which is the maximum speed for the MV widely used nowadays, the capacitor bank of the car from the above example should be able to accumulate no more than 1,000,000 J.

When using the described device in MV traveling in urban areas, and taking into consideration that the maximum permissible speed in settlements is 50 km/h, the energy, liberated at braking, and therefore the capacity and weight of the capacitor banks applied would be many times less.

When using the device in MV it becomes possible that the source of energy is outside the vehicle (Figures 2 and 3), and periodically, when passing over certain zones electric contact is realized between the stationary power source 7 and the indicated device through conductors 8 of the electric contact system and bow collector(s) 9 (like trams and electricity driven trains, but with the difference that the bow collector(s) may be divided into several parts 10, which are electrically separated for the purpose of getting power through two or more conductors 8 from electric contact system; the bow collector(s) may be situated transversely (Fig. 2) or longitudinally (Fig. 3) to the MV). The device is connected to the bow collector(s) 9 through conductors which are not shown on the figures.

Most preferable exemplary design of the invention:

This is the example, described on p. 6 as a first example below the heading "Implementation examples", where all interconnections between the separate units are realized (Fig. 1), and an electric contact system is used as an external electric power source.

Description of the figures:

Figurc 1 represents a general view of the device and the interconnections between the different units.

Figure 2 shows the way of connecting the described device with an external power source through bow collector, situated transversely on the MV. The connection is shown in case of two wires of the electric contact system situated transversally on the road.

Figure 3 shows the way of connecting the device with an external power source through bow collector, situated longitudinally on the MV. The connection is shown in case of two wires of the electric contact system situated transversally on the road.

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Claims:

1. Method for energy accumulation and recuperation in and from motor vehicles making use of a contact electric system, characterized with the fact that energy accumulation and recuperation are done while in motion in points of the electric contact system.

2. Device for energy accumulation and recuperation in motor vehicles, associated with external with respect to the device source(s) of electric energy, if any, consisting of a unit for electric energy control, transformation and re-directing (redistribution), which is connected to the drive (and/or power recuperation) electric motor(s) of the MV, characterized with the fact that the device comprises a capacitor bank, linked to the unit.

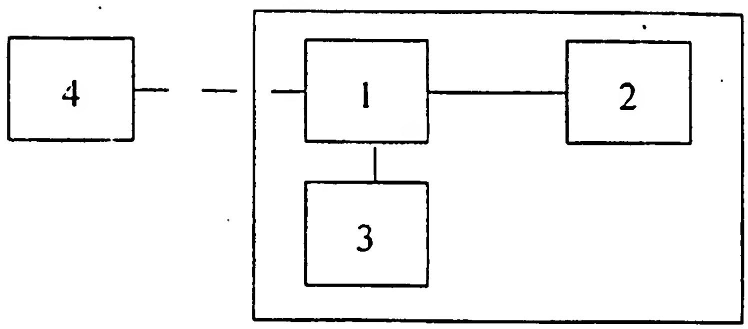

Fig. 1

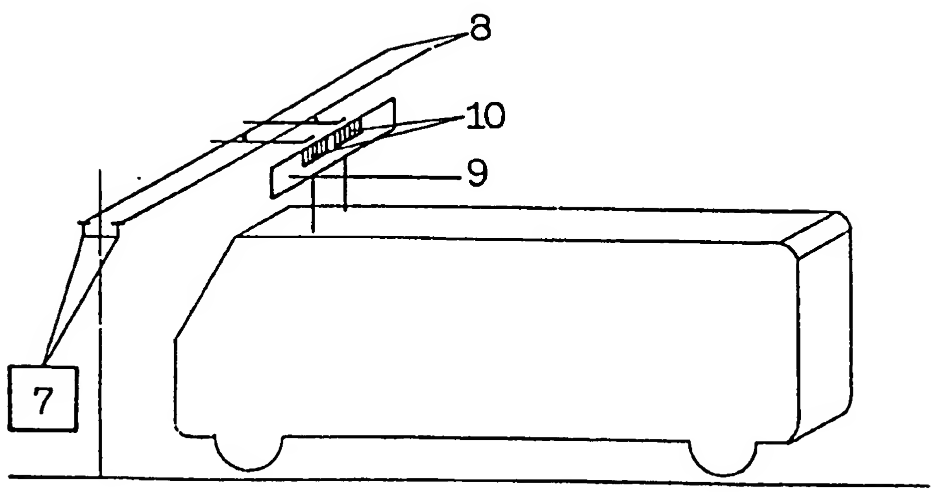

Fig. 2

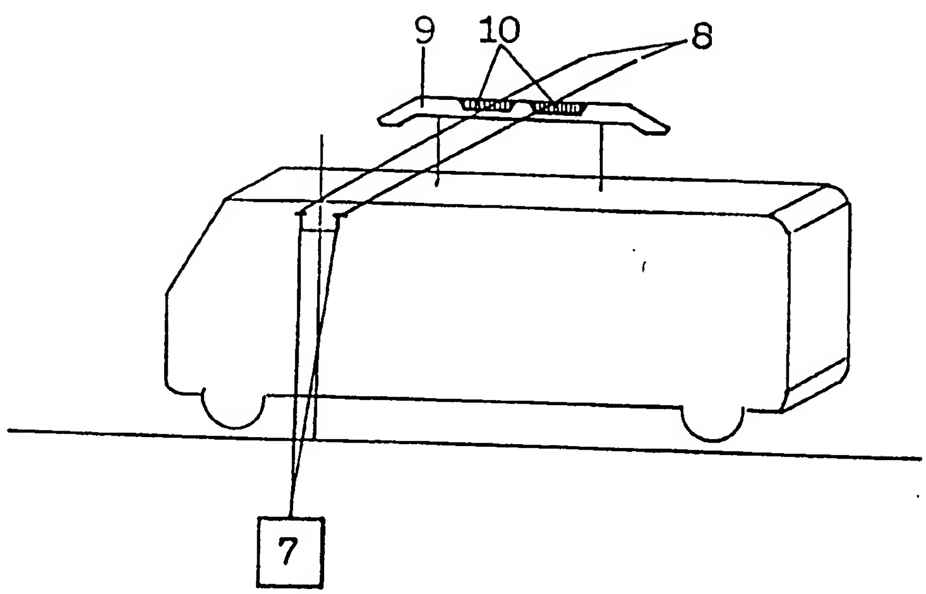

Fig. 3

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60L11/00 B60M7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60L B60M

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Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 21 61 266 A (VETTER FA WALTER) 20 June 1973 (1973-06-20)	1
Y	page 2, paragraph 2	2
Y	EP 0 744 809 A (JEOL LTD) 27 November 1996 (1996-11-27) column 1 -column 3	2

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5 September 2000	13/09/2000

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Information on patent family members

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PCT/BG 00/00012

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